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Advanced Learning Technologies

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2 **Advanced Learning Technologies**

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7 **Synonyms**

8 Artificial intelligence in education; Intelligent tutoring
9 systems; Learning environments; Technology enhanced
10 learning

11 **Definition**

12 Advanced Learning Technologies (ALTs) are artifacts
13 (*technologies*) that enable, support, or enhance human
14 *learning*, emerging from the most recent *advances* avail-
15 able in both areas. There are nowadays two real challenges
16 to be faced when trying to outline in detail this definition
17 of ALTs as a meaningful, full-fledged state of the art of the
18 key concepts for future use, not just an historical overview
19 of socio-technical approaches. The main technical chal-
20 lenge is due to the unprecedented speed of innovation
21 that we notice in Information and Communication Tech-
22 nologies: ICTs; in particular: the Web. The educational
23 challenge is a consequence of the technical one.
24 An account of educational uses of technologies has to
25 consider the impact of ICT innovation onto unexpected
26 changes in human practices in any domain, modifying
27 substantially the classical human learning cycle that since
28 the nineteenth century was mainly considered to be
29 managed within formal teaching institutions such as the
30 schools. Therefore, our interpretation of *advanced* will be
31 in the sense of *dynamic, experimental, to be implemented*
32 *and evaluated* in order to limit the risk that what we
33 describe today as advanced will be considered obsolete in
34 a few months. This vision of ALTs, however, does not
35 underestimate the interest for a reasoned analysis of past
36 experiences. On the one side this analysis will guide us to
37 avoid well-known pitfalls, on the other it will teach us
38 lessons not only about how to exploit the potential learn-
39 ing effects of *current* advanced technologies – the

applicative approach – but also how to envision, elicit, 40
estimate, evaluate the potential promising effects of *new* 41
technologies and settings to be studied and developed 42
within human learning scenarios – the experimental 43
approach – the last, enabling scientific progress both in 44
Informatics and in Psychology of human learning. 45

46 **Theoretical Background**

Advanced Learning Technologies may be described and 47
classified according to different criteria, such as their his- 48
torical development (from the PLATO – TICCIT invest- 49
ments in the 1960s in the US, to current wikis, semantic 50
web and social networks) or their links with disciplinary 51
works (Informatics, Psychology, Pedagogy, etc.). Each and 52
all these classifications are widely available already (► ITS: 53
Intelligent Tutoring Systems or ► AI in Ed: Artificial Intel- 54
ligence in Education or ► IEEE ICALT: International Con- 55
ference on Advanced Learning Technologies). What seems 56
to us interesting here is to present a couple of *new* criteria 57
that may offer a frame of reference for the years to come. 58
Classification criteria should be now different because we 59
are facing a totally different world that is globally 60
connected through the Web where the role of ICTs 61
becomes primary for science, education, and any socio- 62
economic domain. In this sense, most of the remarks in 63
this article are intertwined with the ones in the Web 64
Science one. The core observation is that on the current 65
Web, humans are both consumers and producers of Infor- 66
mation and of Services, i.e., they have a bidirectional 67
access to the Web. Differently said, the modern Web con- 68
sists of some billions of machines *and* of connected peo- 69
ple. In this context, previous definitions are challenged; 70
for instance the classical distinction between technologies 71
and humans (artificial and human autonomous agents) 72
needs to be revisited. 73

Reflecting on each word on turn: let us start with 74
Technologies. It is to be debated if current Information 75
and Communication Technologies (ICTs) are just tech- 76
nologies in the traditional term (artificial tools, artifacts 77
that facilitate the human for the achievement of his/her 78
goals) or rather, represent the modeling substrate of cur- 79
rent and future reality. For instance: social networks are 80
just tools or – by including the millions of humans 81

82 connected – are they a new natural phenomenon, as it is
83 envisaged in the Web Science view? In the latter hypothe-
84 sis: where is the equilibrium between a vision such that
85 humans exploit technologies for their superior needs and
86 the dual one: technologies influence humans in their
87 behavior, an issue that may be classified under the topic
88 of coadaptation? Are these technologies applications of
89 previously defined principles and design rules or rather
90 do they emerge as the evolution of a kind of natural
91 selection process among thousands of options available?

[Aut]

92 In this reflection, the contributions of Eileen Scanlon
93 and Tim O’Shea (2007) and Marc Eisenstadt (2007) are
94 a splendid synthesis of the last 40 years of research, devel-
95 opments, and practical implementations; successes and
96 failures, directions to go and pitfalls to avoid. The main
97 conclusions are that *we now have new topologies for learn-*
98 *ing which have no direct analogues in past educational*
99 *practice* (Scanlon and O’Shea 2007) . . . and *the essence of*
100 *the problem is that new-tech disguising old ideas is almost*
101 *certainly doomed to failure. Learning Management Systems*
102 *and Learning Objects, for example, despite the noble inten-*
103 *tions of many protagonists, can in fact conceal*
104 *neobehaviourist drill-and-practice thinking* (Eisenstadt
105 2007).

106 The subsequent word to be examined is *advanced*. This
107 is rather self-explaining; however, the meaning of the word
108 concerns more likely the exploratory nature of the infra-
109 structures, tools, and practical implementations that one
110 wishes to consider for enabling, supporting, or enhancing
111 human learning. The issue is not so superficial, knowing
112 that often people do not consider that the introduction of
113 technologies in human life, particularly in Education or
114 Learning, implies a profound modification of the human
115 behavior. In principle, radical changes are regarded with
116 suspect by the key actors. In our case, students (learners)
117 are usually ready to accept, while teachers and adminis-
118 trators resist to the introduction of changes as most pro-
119 fessionals often do with respect to innovation (other
120 historical examples being technologies for health or for
121 the legal professions). Therefore, *advanced* suggests a life
122 cycle of innovation that cares for an experimental part:
123 similar to a spiral (software development) approach based
124 on trial and error as opposed to the waterfall one, in order
125 to *motivate and convince* the actors of their own interest to
126 adopt changes in their practice. No major change in the
127 work practice will ever occur if it is not preceded by an
128 experimentation that puts the actors and their motivation
129 and awareness at the center of the implementation itself.
130 Some authors even reverse the argumentation by propos-
131 ing to exploit the proactivity of humans in open partici-
132 patory learning infrastructures – *serendipitous mashups*

133 *foster creative integration* (Eisenstadt 2007). Anyway, the
134 classical concepts of ICT products optimizing the acqui-
135 sition of knowledge and skills by interactive training are
136 challenged by more modern concepts of peer-to-peer ser-
137 vices adapting to the partner’s needs and collaborating in
138 social networks in order to facilitate learning. More often
139 as before, those modern socio-technical scenarios enable
140 human learning that otherwise would be impossible to
141 conceive, so that the administrator’s right question
142 becomes more *what would happen if we do not use tech-*
143 *nologies for learning* as the traditional question: *why should*
144 *we use them?*

145 Thirdly, we are interested in *learning technologies* in the
146 sense of human learning. However, we know very little
147 about human learning. The relation teaching-learning
148 (effects of teaching) is not always clear (see, e.g., *the no*
149 *significant difference phenomenon* Web site: [http://www.](http://www.nosignificantdifference.org/)
150 [nosignificantdifference.org/](http://www.nosignificantdifference.org/)). We are facing a kind of
151 dichotomy between a natural process (human learning)
152 and the practice supposed to facilitate it (teaching). The
153 opposition is similar to the one of biology versus medi-
154 cine: practicing medicine is not worth unless the patient is
155 healed. Similarly, the only interest of teaching is in its
156 effects: that learners indeed learn. Medicine is an art
157 while biology is a natural science; we will never better
158 our practices in medicine unless we better understand
159 the underlying biological phenomena concerned. For
160 those reasons, it is important to admit that technologies
161 for teaching do not necessarily imply better or different
162 learning. A vision of human learning may have
163 a substantial influence on the priorities to attribute to
164 the development of technologies for learning, the most
165 radical difference being the one between behaviorism,
166 constructivism and social constructivism which are
167 treated extensively elsewhere in this encyclopedia.

168 Important Scientific Research and Open 169 Questions

170 The most important scientific research question concerns
171 which discipline profits from the success of the interdis-
172 ciplinary projects in ALTs. These profit from disciplinary
173 competences of humans, and may produce advances in
174 each discipline but in quite different proportions
175 according to the choices made in the goals, plans etc.,
176 adopted for the research process. In making progress in
177 ALT, does one produce advances in understanding learn-
178 ing, thus improving as a side-effect teaching practices, or
179 rather the technologies experimentally developed in edu-
180 cational or learning scenarios are significant for progress
181 in Informatics? One of the most interesting paradigm
182 shifts in current Web Technologies and Web Science is

183 that new usage-centered business processes do require to
184 introduce interoperability among machines and people
185 but reuse old technologies. Another is that social software
186 success is hardly to be forecasted and may not be stable,
187 will rather be dynamic, evolving, and volatile. So it is the
188 case for the learning effect of informal learning situations
189 such as those offered by the Web. The acceptance is also
190 variable with the age: digital natives behave differently as
191 digital immigrants independently from their role of stu-
192 dents, teachers, or administrators. Within this totally new
193 framework, the real open question concerns what are the
194 established principles that we may assume as valid and
195 how to progress.

196 For instance, in the Bioinformatics of genome it is well
197 known that the main effect is a progress in understanding
198 the genome; minor effects though exists in the availability
199 of efficient algorithms for generic purposes (advances in
200 Informatics). The opposite case considers the business
201 domain (human learning in our case) as a *scenario* for
202 the elicitation of new ideas (not as an application
203 domain): an example being the seminal work done by
204 Alan Kay around the Dynabook as well as Smalltalk in
205 the early 1970s. Fundamental advances in Informatics
206 research (the personal computer, the first real object ori-
207 ented programming language, the window interface, the
208 integrated environment including the language and the
209 interface, etc.) emerged from observations about the needs
210 of children (the dynamic book; the small talk for small
211 children) with an enormous impact in the 40 following
212 years. Similarly, the PLATO system conceived in the 1960s
213 by Don Bitzer and Paul Tenczar for military and educa-
214 tional purposes was a precursor of many currently
215 used generic interactive technologies: the PLASMA flat
216 512 × 512 dot graphic display with images superimposed
217 projected from a microfiche of color slides; an operating
218 system with a kind of virtualization of student's variables,
219 enabling in the 1970s the remote access of up to 1,000
220 simultaneous users, the TERM-TALK option for chatting,
221 the interactive TUTOR programming language that later
222 became TENCORE for PCs, etc. On the opposite side,
223 TICCIT was an early example of pure exploitation of the
224 television for distance education with no real ambitions of
225 advances in technologies.

226 In the case of ALTs, the most important advances
227 concerned with modeling human learning have been
228 obtained as a consequence of the need to tune (or adapt)
229 interactions to individual learners. As Artificial Intelli-
230 gence has demonstrated, modeling complex natural phe-
231 nomena implies understanding them better. In the case of
232 learner modeling, it means understanding better human
233 learning. The domain of learner modeling, opened by the

234 foundational work of John Self (1974) has been at the core
235 of years of quite profound research of generic impact for
236 human-computer interaction, where models have
237 represented human competence, human skills and, more
238 recently, human emotions and personality traits. Adapt-
239 able interfaces are now among the top priorities of any
240 modern ICT application.

241 However, the fundamental question on ALTs still
242 remains, after more than 50 years of research and practice.
243 The question is if ALTs are concerned with a more efficient
244 production of teaching material by using technologies, as
245 it was the case for the CAI (Computer-Assisted Instruc-
246 tion or its synonyms) that basically attempt to mimic the
247 schoolteacher in transmitting content and examining the
248 acquisition of the subject matter, or rather are called for
249 stimulating learning by dialogue and interaction in any
250 area (learning environments), such as it is the case for
251 (serious) games, social networks, communities where
252 learning may occur as a side effect of social interaction.
253 In order to have once more a direct answer, one may refer
254 to the arguments of one of the pioneers: John Seely Brown.
255 Related to this question, the distinction is sometimes
256 made between formal and informal learning. In the first
257 case, today's focus is ontologies (the intensional represen-
258 tation of concepts and relations for reasoning, problem
259 solving, and search), instructional design and experiments
260 on the learning effects due to teaching strategies. In the
261 second case the issues are interaction design, dialogue
262 management and the evaluation of the success by other
263 parameters such as motivation, implication in social net-
264 works, and professional impact of the actors. It is certain
265 that both approaches are synergic to one another.

266 While Artificial Intelligence may pervade each of the
267 approaches, it does it in very different ways. In order to
268 understand how pioneers paved the way for radical
269 changes in the research and practice on ALTs, we refer to
270 the inspiring paper of Jaime Carbonell (1970): the notion
271 of mixed initiative dialogue has introduced a shift in the
272 conception of classical, previous educational software
273 (such as the one produced on PLATO) by requiring the
274 *automated tutor* to understand the learner's question,
275 needs, and statement. While in the beginning this was
276 supposed to require just some natural language software
277 able to recognize *WH- questions*, later the approach
278 opened the research agenda on user models and, in gen-
279 eral, on dialogues including models of the pragmatics of
280 conversations such as those typical of modern Agent
281 Communication Languages (performatives, speech acts).

282 As a conclusion, ALTs are at the core of questions and
283 answers that have challenged informaticians since the
284 1960s. ALTs have historically been prototypical for most

285 innovations in interaction models and technologies as well
286 as, nowadays, in interactive, multi-centric, heterogeneous,
287 asynchronously communicating service-oriented business
288 (learning) processes (Cerri et al. 2005; Ritrovato et al.
289 2005). In its essence, the question concerns how to *design*
290 *interactions* suitable to have effects on a human partner in
291 conversations where the meaning of design is far from the
292 rigid definition of classical workflow and more in the sense
293 of exploiting open interactions for enhancing learning.
294 This scientific question fits well with very modern issues
295 (service-oriented computing: semantics, processes,
296 agents). A service is different from a product in the sense
297 that it is produced on the fly when required by the con-
298 sumer (dynamic) and its effectiveness is measured by the
299 consumer's satisfaction, not just by its intrinsic perfor-
300 mances. This recent paradigm shift in Informatics fits
301 better with the above mentioned concepts of conversa-
302 tions among autonomous agents (such as teachers,
303 learners, or other actors in the community of practice)
304 where the dimension of heterogeneity of knowledge, com-
305 petence, skills and motivation, the distribution of
306 resources and interests, the asynchronous communication
307 channels and patterns, the coexistence of artificial and
308 human agents in the collaborative efforts, the ubiquity of
309 bidirectional access worldwide ought to be considered
310 components of a Web Science scenario where learning
311 occurs everywhere at any time rather than classical ICT
312 products in a traditional classroom equipped with some
313 computers.

Cross-References

► Interactive Learning Services	314
► Learning as a Side Effect	316
► Serious Games	317
► Social Networks	318
► Web Science	319

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